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Grebnev et al.

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(54) **FLOW-RATE CONTROLLER**

OTHER PUBLICATIONS

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Cosmonautics Encyclopedia; Moscow; 1985, p. 16.

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patent is extended or adjusted under 35  
U.S.C. 154(b) by 0 days.

(57) **ABSTRACT**

(21) Appl. No.: **09/405,696**

A flow-rate controller comprises hollow casing 1, main 2  
and additional 3 outlet branch pipes, and outlet branch pipe  
4. Piston-type slide valve 13 with skirt 14 is located between  
front 5 and rear 10 guide bushes. The starting fuel compo-  
nent flows through the controller via branch pipe 3, hole 22,  
inlet space 7, holes 24 and 23, passage space 8, outlet  
orifices 11 and outlet branch pipe 4. It is followed by the  
main fuel component supplied to the system through the  
controller via branch pipe 2, open nonreturn pressure control  
valve 27, open front orifices 9, passage space 8, outlet  
orifices 11 and outlet branch pipe 4. Constant rates of flow  
of both the starting and the main fuel components through  
the controller are assured by the aforesaid original design  
slide valve and by the corresponding channels.

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**<sup>7</sup> ..... **F16K 1/12; G05D 7/01**

(52) **U.S. Cl.** ..... **137/220; 137/501**

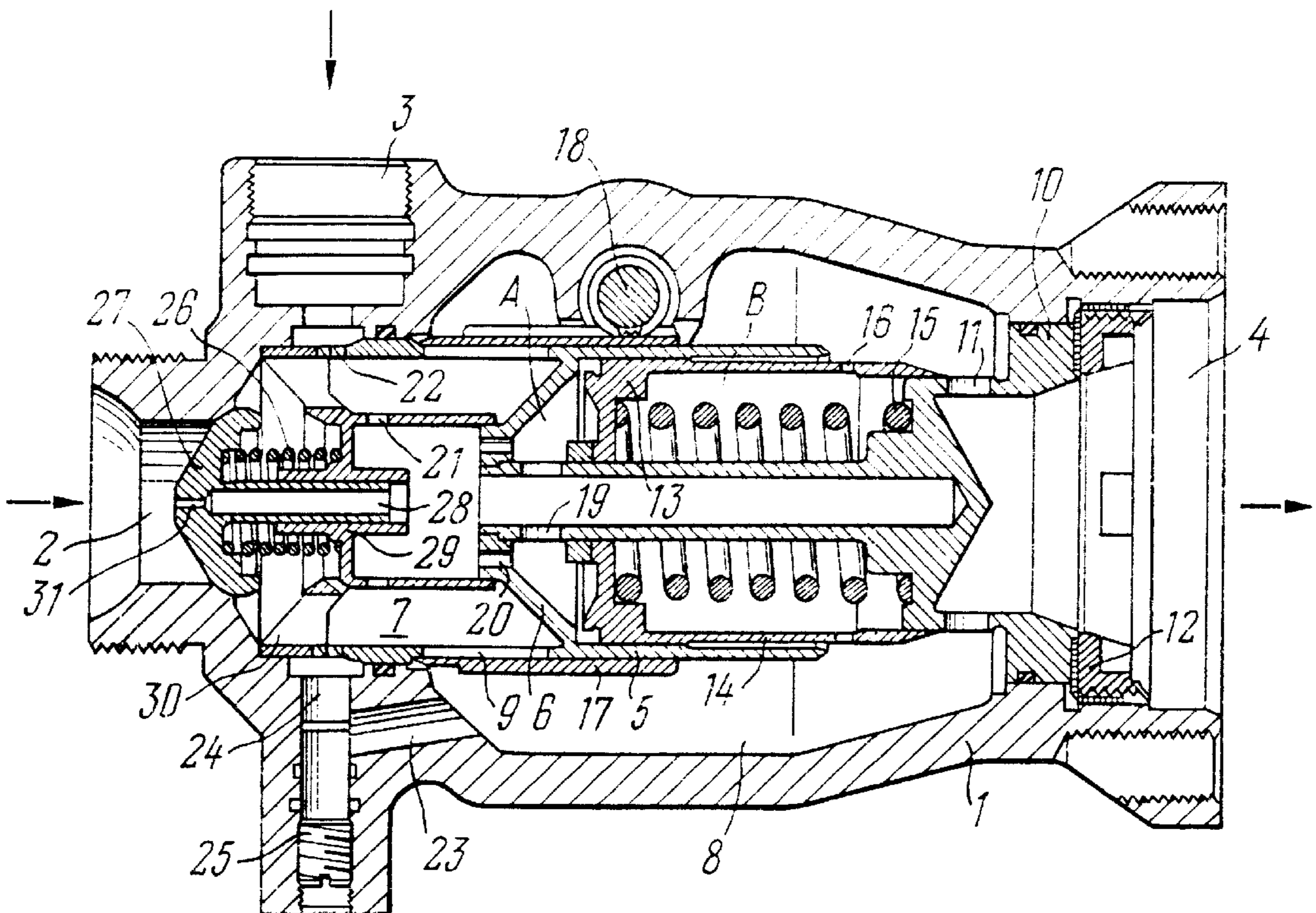
(58) **Field of Search** ..... **137/220, 501**

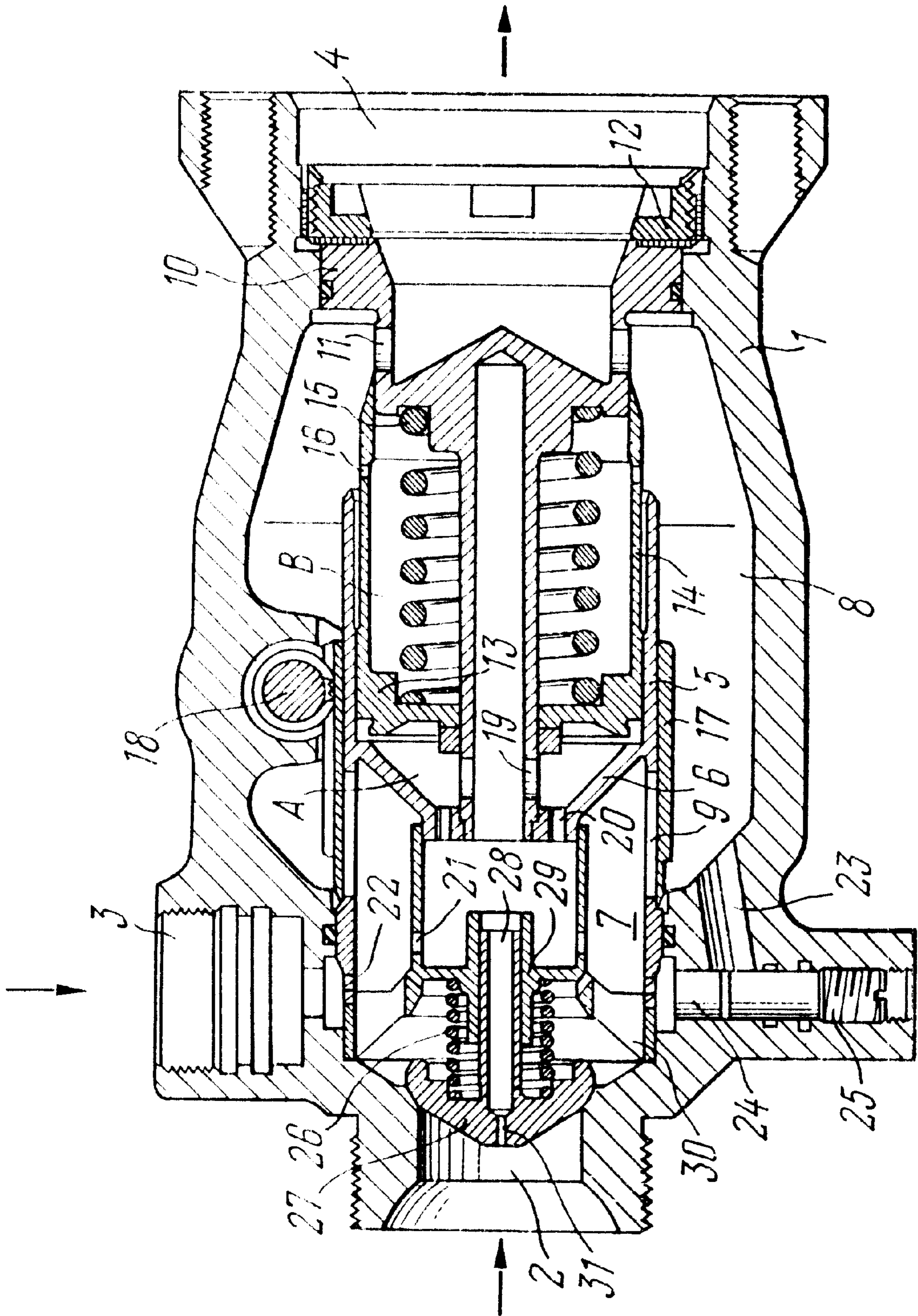
(56) **References Cited**

**U.S. PATENT DOCUMENTS**

3,130,747 4/1964 Benaway .

**3 Claims, 1 Drawing Sheet**





**FLOW-RATE CONTROLLER****FIELD OF THE INVENTION**

The present invention relates to automatic equipment and, more specifically, to flow-rate controllers mounted in hydraulic systems of power plants, for instance, in regulator systems of liquid-propellant rocket engines.

**BACKGROUND OF THE INVENTION**

Known in the art is a flow-rate controller (U.S. Pat. No. 3,130,747, Cl. 137-504, 1964) comprising a spring-loaded slide valve communicating with the inlet space of the unit from one side, and with the internal space of the controller through openings in the slide valve from the other side. This controller assumed to be similar to the present invention is deficient in that it is designed for operation under constant flow rate conditions and cannot assure the manifold operation in different modes.

Prior art also includes a liquid flow-rate controller which is made in the form of a casing with the main inlet and outlet branch pipes and comprises: a stationary front guide bush with front orifices and with a lateral partition limiting the internal space of said bush to form an inlet space communicating directly with the main branch pipe; a sleeve arranged coaxially in said front guide bush and caused by a mechanically connected actuator to slide therein with a possibility of covering the front orifices; a stationary rear guide bush located in line with the front guide bush and having outlet orifices in its walls; a piston-type slide valve with skirt arranged between said lateral partition and said rear guide bush to form a piston space limited by said lateral partition, the piston being spring-loaded on the side of the rear guide bush and capable of making contact with said lateral partition; a passage space formed between the casing and said front and rear guide bushes whereby the inlet space communicates with the outlet branch pipe via the front and outlet orifices. The holes provided in the aforesaid piston skirt enable the skirt cavity to communicate with the passage space, and the rear portion of the skirt which is a free fit on the rear guide bush can cover the latter's outlet orifices ("Cosmonautics" Encyclopedia, Sovetskaya encyclopedia, 1985, p. 16, FIG. 9).

The disadvantage of this controller which represents the closest prior art of the claimed invention consists in that the rate of liquid flow through the gaps between the controller parts at further reduction of the minimal flow rate becomes commensurate with the rate of liquid flow through the throttling device, wherefore the accuracy in the setting of the required flow rate diminishes appreciably, particularly at the low power setting, which is of special importance in the engine starting mode.

Besides, the known controller calls for special devices making it possible to change the engine fuel supply from an additional inlet branch pipe (the starting tank) to the main inlet branch pipe (main fuel manifold).

**OBJECTS OF THE INVENTION**

It is an object of the present invention to eliminate the above-mentioned disadvantages by providing a flow-rate controller capable of starting the engine at a fixed setting of the fuel control device (shaft) and assuring a higher accuracy of the additional supply of working medium to the flow-rate controller.

It is another object of the present invention to improve the accuracy of the flow-rate controller operation at engine low

power and permit changing the controller supply from an additional inlet branch pipe to the main inlet branch pipe.

**SUMMARY OF THE INVENTION**

In accordance with these objects, the present invention resides in that a liquid flow-rate controller which is made in the form of a casing with the main inlet and outlet branch pipes and comprises: a stationary front guide bush with front orifices and a lateral partition limiting the internal space of said bush to form an inlet space communicating directly with the main branch pipe; a sleeve arranged coaxially with said front guide bush and caused by a mechanically connected actuator to slide ever and along it with a possibility of covering the front orifices; a stationary rear guide bush located in line with the front guide bush and having outlet orifices in its walls; a piston-type slide valve with skirt arranged between said lateral partition and said rear guide bush to form a piston space limited by said lateral partition, the piston being spring-loaded on the side of the rear guide bush and capable of making contact with said lateral partition; a passage space formed between the casing and said front and rear guide bushes whereby the inlet space communicates with the outlet branch pipe via the front and outlet orifices, the holes in the aforesaid piston skirt enabling the skirt cavity to communicate with said passage space, and the rear portion of the skirt fitted freely on the rear guide bush having a possibility to cover the latter's outlet orifices, is provided additionally with a nonreturn valve and a throttle adjuster arranged in the channel connecting said inlet space with said passage space, and the controller casing is provided additionally with an inlet branch pipe arranged in the front portion of said casing and connected to the inlet space through the inlet holes in said front guide bush fitted in a controllable sleeve, said nonreturn valve being mounted in said main inlet branch pipe on the side of said inlet space, and said lateral partition being provided with holes to connect said inlet space with said piston space.

The nonreturn valve is a spring-loaded mushroom type with a stem arranged in the guide sleeve. The sleeve is installed on pylons located in the inlet space and secured on the front guide bush, whereas the mushroom-like head of the nonreturn valve is provided with an axial opening to maintain a partial vacuum in engine spaces.

The nature of the invention is further described in detail with reference to the accompanying drawing (FIG. 1) representing a longitudinal section of a flow-rate controller embodiment.

The disclosed flow-rate controller comprises hollow casing **1** with main **2** and additional **3** inlet branch pipes, as well as outlet branch pipe **4**. Main branch pipe **2** serves to supply the main fuel component, and additional inlet branch pipe **3**, the starting fuel component.

The front portion of casing **1** accommodates rigidly fastened front guide bush **5** made integral with lateral partition **6**, the inner cavity of said front guide bush representing inlet space **7**. Passage space **8** formed between front bush **5** and the inner surface of casing **1** communicates with inlet space **7** via front orifices **9** made in the walls of bushing **5**.

The rear portion of casing **1** accommodates rear guide bush **10** rigidly fastened in line with the front guide bush. Outlet orifices **11** made in the walls of the rear bush connect passage space **8** with outlet branch pipe **4**.

The rigid position of front guide bush **5** and rear guide bush **10** in respect of casing **1** is assured by nut **12** tightened to a positive stop.

The space between front guide bush **5** and rear guide bush **10** is occupied by the slide valve made in the form of piston **13** with skirt **14**. Piston **13** loaded by spring **15** thrusts against rear guide bush **10** and maintains contact with the inner surface of the rear portion of front guide bush **5**. Piston skirt **14** is provided with holes **16** and the rear portion of said skirt is fitted freely on rear guide bush **10** being thus capable of covering the latter's outlet orifices **11**.

Sleeve **17** fitted on front guide bush **5** is linked to actuator **18** which causes said sleeve to slide along bush **5** with the possibility of covering front orifices **9** in said bushing. Actuator **18** may be an electric motor (not shown in the Figure), its shaft being connected to sleeve **17** through a rack gearing.

Piston space A formed between partition **6** and piston **13** communicates with additional inlet branch pipe **3** via holes **19**, **20**, **21** and **22**. Space B on the side of the skirt of piston **13** also communicates with inlet branch pipe **3** via holes **16**, passage space **8** in casing **1**, holes **23** and **24**, inlet space **7** and hole **22**. The fuel passage between holes **23** and **24** is controlled by a throttle adjuster which is essentially adjusting screw **25**.

Main inlet branch pipe **2** carries nonreturn pressure control valve **27** installed on the side of inlet space **7**. This valve comprising a mushroom-like head and stem **28** is loaded with spring **26**. The stem is arranged in guide sleeve **29** which is installed on pylons **30** located in inlet space **7**. Mushroom head **27** is provided with axial opening **31**.

The proposed controller operates as follows:

The fuel starting component supplied to inlet branch pipe **3** fills passage space **8** via holes **22**, **24** and **23** and flows further to the engine via outlet orifices **11** and outlet branch pipe **4**. The flow of the starting fuel component into main inlet branch pipe **2** is prevented by spring-loaded mushroom head **27** held against its seat in controller casing **1**, whereas front orifices **9** are covered by sleeve **17** held against the end face of bush **5** by the axial thrust of actuator **18**.

The required flow area between holes **23** and **24** is set at the factory by adjusting screw **25**. The rate of flow of the fuel starting component is determined by the passage area of the fuel supply channel and the differential pressure across it. Hence, in order to maintain the constancy of the rate of flow of the fuel starting component set by adjusting screw **25** it is necessary to assure a constant difference of pressures at the channel inlet and outlet. To this end, the pressure of the fuel starting component built up in the cavity with hole **24** is also applied to space A (via holes **21**, **20** and **19**), and the pressure built up in the cavity with hole **23**, to space B (via passage space **8** and holes **16** in piston skirt **14**). The rated difference of pressures maintained in spaces A and B and, consequently, the constancy of the fuel flow rate is attained owing to a balance of the force of spring **15** and the force applied to slide valve piston **13**. In the event of any random deviation of the aforesaid pressure differential the balance of forces is disturbed and piston **13**, moving in one or another direction, partially covers or uncovers outlet orifices **11**. As a result, the rated pressure differential across slide valve piston **13** and, consequently, the desired rate of flow of the fuel starting component through the regulator is restored back to normal.

In order to change to the fuel main component, actuator **18** moves sleeve **17** which partially uncovers front orifices **9**. The fuel main component supplied through inlet branch pipe **2** forces the mushroom head of nonreturn pressure control valve **27** off its seat in casing **1**, enters the controller

and passes into the engine. Further displacement of sleeve **17** increases the rate of flow of the fuel main component through the controller to the set value.

If the pressure grows, a special device, e.g. a check valve (not shown in the Figure) cuts off the manifold of additional branch pipe **3** and terminates further supply of fuel through it.

As is seen from the above description, uniform operation of the main and starting manifolds provided by the disclosed flow-rate controller is based on one and the same principle.

Axial hole **31** made in mushroom valve **27** serves to assure a complete discharge of the controller inner cavity during the test of system components by the manufacturer.

#### Industrial Applicability

The flow-rate controller is designed for liquid pipelines, primarily in liquid-fuel rocket engines. It can be also used in different plants and installations employing liquid pipelines.

The invention is claimed as follows:

1. A liquid flow-rate controller made in the form of a casing with the main inlet and outlet branch pipes comprising:

a stationary front guide bush with front orifices and a lateral partition limiting the internal space of said bush to form an inlet space communicating directly with the main branch pipe; a sleeve arranged coaxially with said front guide bush and caused by a mechanically connected actuator to slide over and along it with a possibility of covering the front orifices; a stationary rear guide bush located in line with the front guide bush and having outlet orifices in its walls; a piston-type slide valve with skirt arranged between said lateral partition and said rear guide bush to form a piston space limited by said lateral partition, the piston being spring-loaded on the side of the rear guide bush and capable of making contact with said lateral partition; a passage space formed between the casing and said front and rear guide bushes whereby the inlet space communicates with the outlet branch pipe via the front and outlet orifices, a plurality of holes in the aforesaid piston skirt enabling a skirt cavity to communicate with said passage space, and the rear portion of the skirt being fitted freely on the rear guide bush with a possibility of covering the latter's outlet orifices; a nonreturn valve and a throttle adjuster arranged in a channel connecting said inlet space with said passage space; and an additional inlet branch pipe arranged in the front portion of said casing and connected to said inlet space through a plurality of inlet holes in said front guide bush fitted in a controllable sleeve, said nonreturn valve being mounted in said main inlet branch pipe on the side of said inlet space, and said lateral partition being provided with holes to connect said inlet space with said piston space.

2. A liquid flow-rate controller as claimed in claim 1, wherein the nonreturn valve is a spring-loaded mushroom type with a stem arranged in the controllable sleeve, said sleeve being installed on pylons located in the inlet space and secured on the front guide bush.

3. A liquid flow-rate controller as claimed in claim 2, wherein the mushroom-like head of said nonreturn valve is provided with an axial opening.

UNITED STATES PATENT AND TRADEMARK OFFICE  
**CERTIFICATE OF CORRECTION**

PATENT NO. : 6,230,734 B1  
DATED : May 15, 2001  
INVENTOR(S) : Grebnev et al.

Page 1 of 1

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Title page.

Item [73], Assignee, please delete "Aktsioneirnoe" and insert -- Aktsionerno --;  
please delete "Nauchno proizvodstvennoe obiedinene" and insert -- Nauchno-  
Proizvodstvennoe Obiedinenie --.

Signed and Sealed this

Twenty-second Day of March, 2005

A handwritten signature in black ink on a light gray dotted background. The signature reads "Jon W. Dudas" in a cursive style.

JON W. DUDAS

*Director of the United States Patent and Trademark Office*